# PROPERTIES AND LIQUEFACTION RISK ON BULK CARGO CARRYING BUKIT GOH, KUANTAN BAUXITE ACCORDANCE TO IMSBC CODE

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I hereby declare that I have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Civil Engineering.

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Thesis submitted in fulfilment of the requirements
for the award of the degree of
B.Eng (Hons) in Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2018

# DEDICATION

**Dedicated to my parents; Abdullah Koya and Nortepah Kasim**

## ACKNOWLEDGEMENT

Firstly, I would like to thank God for His greatness for lending his power all these while for me to complete this Final Year Project course.

I am grateful and would like to express my sincere gratitude to my supervisor, Assoc. Prof. Dr. Muzamir Hasan for his germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research a success. With his outstanding professional conduct, his patience and availability to guide has impressed and inspired me. I am sincerely thanks and appreciated him for all the guidance, time spent proofreading and patiently correcting my mistakes while doing this research. His wide knowledge, experiences and skills has allowed me to perform better and sharpen my capabilities in many areas, especially in the field of Geotechnical Engineering. My sincere thanks goes to my lab mate, Noraishah Binti Lamin who helps a lot in carrying out the laboratory testing throughout this research.

My sincere thanks to all the lab assistants in Soil and Geotechnics Laboratory Universiti Malaysia Pahang, En. Ziunizan, En. Nor Azmi and En. Haliman, who provided me trainings and equipment during my laboratory testing to complete my project. An appreciation goes to all my laboratory mates and fellow undergraduate student for their cooperation, idea, discussion and continuous support throughout my research as their helps are important for the completeness of this project.

Finally, sincere acknowledgment goes to my parents, for all their sacrifices, support and love for whom I am today. I acknowledge my siblings for all their support through hard times and hard days and also encouragement in completing this research work.

## ABSTRACT

This study focus on the differences of geotechnical properties between raw and processed Bukit Goh bauxite. As bauxite material has high clay content which mostly composed of silicate minerals, it has high risk to cause cargo liquefaction which in turn causes catastrophic incident. This paper includes the analysis of raw and processed bauxite where its fine particle contents has been minimized using beneficiation method to reduce the risk of liquefaction by referring to the International Maritime Solid Bulk Cargoes Code (IMSBC Code) standard. To analyze these characteristics of the bauxite, four samples were selected at Bukit Goh, Kuantan; two of the samples from the Bukit Goh mine and two samples from stock pile were tested to identify the bauxite geotechnical properties by referring to GEOSPEC 3: Model Specification for Soil Testing; particle size distribution, moisture content, specific gravity, morphological properties as well as its elemental and oxide properties. Laboratory tests involved including Small Pycnometer test, Dry Sieve test, Specific Gravity test, X-ray fluorescence test (XRF) and Field emission scanning electron microscopy test (FESEM). The results show that average moisture content of raw bauxite is 24.33% which exceeded the recommended value of maximum 10% while the average moisture content of processed bauxite is only 7.16%. The average fine material for raw bauxite is 38.50% which should not be greater than 30% per IMSBC standard while for processed bauxite is 21.40%. From the FESEM image, it was clearly shown that the fine particles of processed bauxite is lesser than raw bauxite. In conclusion, the quality and safety of processed bauxite is better than raw bauxite.

# ABSTRAK

Kajian ini memberi tumpuan kepada perbezaan ciri-ciri geoteknik dan ciri-ciri morfologi diantara bijih bauksit Bukit Goh yang mentah dengan yang telah diproses. Bijih bauksit mengandungi kandungan tanah liat yang tinggi dimana ia terdedah kepada risiko yang tinggi untuk fenomena likuifaksi kapal kargo untuk berlaku yang boleh mencetuskan kemalangan yang serius. Kajian ini mengandungi analisa bauksit mentah dan bauksit yang telah diproses dimana zarah halusnya teleh dikurangkan melalui proses benefikasi untuk mengurangkan risiko likuifaksi kapal kargo dengan merujuk kepada Kod Maritim Antarabangsa Kargo Pukal Pepejal (Kod IMSBC). Bagi menganalisa ciri-ciri bauksit ini, lima sampel telah diambil dari Bukit Goh, Kuantan, tiga daripada sampel itu adalah dari kawasan lombong Bukit Goh, dan dua daripada simpanan stok dimana kesemuanya diujikaji untuk mengetahui ciri-ciri geotekniknya dengan berpandukan kepada GEOSPEC 3: Model Spesifikasi untuk Ujian Tanah (Model Specification for Soil Testing); taburan saiz zarah, kandungan kelembapan, berat jenis, sifat-sifat morfologi dan juga ciri-ciri elemen dan oksida. Ujian makmal yang terlibat adalah ujian Piknometer Kecil, ujian Ayak Kering, ujian berat jenis, ujian XRF dan ujian FESEM. Keputusan analisis mengindikasi bahawa purata kandungan lembapan tanah mentah adalah 24.33% yang mana ia melebihi nilai maksima yang disyorkan iaitu 10% manakala purata kandungan lembapan tanah yang diproses adalah 7.16% sahaja. Taburan purata saiz zarah halus bauksit mentah adalah 38.50% dimana ia melebehi peratusan 30% yang dinyatakan dalam kod IMSBC manakala 21.40% bagi bauksit yang telah diproses. Dari gambar FESEM, ia menunjukkan bahawa zarah halus bauksit diproses adalah kurang berbanding dengan bauksit mentah. Kesimpulannya, tahap kualiti dan keselamatan bauksit yang diproses lebih baik dari bauksit mentah.

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| | |
|---|---|
| $c'$ | Cohesion angle |
| $o'$ | Friction angle |
| $\tau_f$ | Effective stress |
| $u$ | Pore water pressure |
| $\omega$ | Moisture content |
| $c'$ | Cohesion angle |
| $\%$ | Percentage |
| $mm$ | Millimeter |
| $m$ | Meter |
| $g$ | Gram |
| $kg$ | Kilogram |
| $°C$ | Degree Celsius |
| $\mu m$ | Micrometer |

# LIST OF ABBREVIATIONS

| | |
|---|---|
| Al | Aluminium |
| ASTM | American Society for Testing and Materials |
| Fe | Iron |
| FESEM | Field Emission Scanning Electron Microscope |
| IMSBC | International Maritime of Solid Bulk Cargoes |
| LI | Liquidity Index |
| LL | Liquid Limit |
| Na | Sodium |
| O | Oxygen |
| pH | Potential Hydrogen |
| PI | Plasticity Index |
| Ti | Titanium |
| Si | Silicon |
| XRF | X-Ray Fluorescence |

# CHAPTER 1

# INTRODUCTION

## 1.1 BACKGROUND OF RESEARCH

Malaysia is well-gifted with natural resources like petroleum, timber, copper, iron ore, natural gas and not to forget, bauxite. Recently, the numbers of growing producer of bauxite due to the rapid development of aluminium are quite astonishing. After iron, aluminium is now the second most widely used metal in the world resulting the increasing demand of bauxite which is the principal ore of the aluminium production. Aluminium is all around us in everyday life in buildings, boats, planes and cars, household appliances, packaging, computers, hand phones, containers for food and beverages.

Aluminium will continue to be an important metal for the future because it is good potential for recycling. We may not think about the qualities of aluminium that contribute to the products we rely on, but we benefit from them frequently. Aluminium is the most abundant metal in the crust of the earth and also can be recycled repeatedly while maintaining its quality, so it is an environmentally friendly choice for many products. It does not rust, is not magnetic and it conducts both heat and electricity with ease. It is light and more easily shaped than many other metals while still staying remarkably strong. Adaptable and practical, aluminium is often brought to our daily life through the process of aluminium extrusion.

Bauxite is a raw material used in the production of alumina and, subsequently, aluminium. Like many metals, world demand for aluminium, and therefore bauxite, has grown substantially over the past 10 years in response to economic growth in emerging Asian economies. Bauxite is a relatively soft ore with a distinctive reddish brown colour. This colour makes it easy to spot a bauxite mining area (Roskill, 2014).

Figure 1.1 shows the world production of bauxite and alumina. In 1999, the world produced 129 million mt of bauxite from which 50.2 million mt of alumina were refined. For 2014, the totals were estimated at 234 million mt and 108.4 million mt, respectively, but while the output of alumina rose slightly from 2013, bauxite production fell by more than 50 million mt as a direct result of the Indonesian export ban. The yield of alumina from raw bauxite has remained virtually unchanged at a little more than 38% over this period, on average, the grade of bauxite resources being mined has also been maintained. Unlike some other commodities, the bauxite industry does not yet appear to be faced with a declining long-term grade profile (The International Aluminium Institute, 2012).

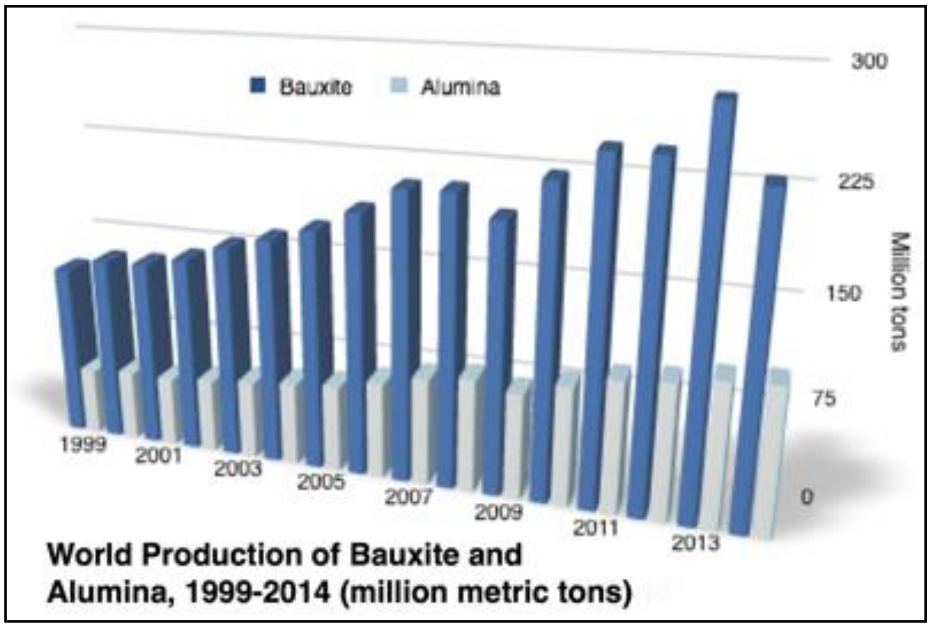


**Figure 1.1**: World Production of Bauxite and Alumina

Source: Bauxite and Alumina Growth Maintained (2014)

In 2014, China, the world's largest alumina and aluminium producer, lost a significant supplier of bauxite to feed its alumina refineries following Indonesia's decision to implement a ban on the export of unprocessed ores. As such, the industry turned to Malaysia in an attempt to fill the void. Malaysia's ability to rapidly increase its output was demonstrated by its production soaring almost 600% from 2014 to 2015.

Malaysia represented China's largest trading partner accounting for 45% of all bauxite delivered in 2015. In the same year, China produced just over half of the world's aluminium and its demand for bauxite has been increasing year-on-year. In 2015, the top five metallurgical bauxite producers were Australia, China, Brazil, Malaysia and India.

Malaysia is currently the fastest growing producer of bauxite due to the rapid development of bauxite mines in the Pahang coastal region. Due to high demands from China, within only 18 months, the mining and extraction of Bauxite has caused extreme physical wear on the environment. Founding of new bauxite deposition at Kuantan, Pahang had become an economically attractive and a major issue in Malaysia. There are several aluminium mines that had been identified all around Malaysia such as Bukit Batu and Bukit Gebong at Sarawak, Bukit Mengkabau at Sabah and Bungai Rengai at Johor (Tse, 2004).

This study is mainly about bauxite properties; basic properties and chemical properties for the bauxite sample taken at bauxite mine in Bukit Goh, Kuantan, Pahang. Bauxite mining at Kuantan had become a major issue for Pahang State Government. As the end-product of bauxite only being exposed, people tend to recognize aluminium rather than bauxite. Therefore, bauxite mining at the area contributes to anxiety of locals as the mines are located near to residential area.

The area of study is a residential area which now had turn into economically attractive to bauxite miners and company to establish their collected plant before it is transported to smelter plant. Thus, it is important to carry out the study on this area to determine whether the bauxite at this area is suitable for export and does bauxite properties may harmful to human.

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